Kinetic Integrated Thermal Protection System (KnITPS) (KniTPS)

Completed Technology Project (2012 - 2012)

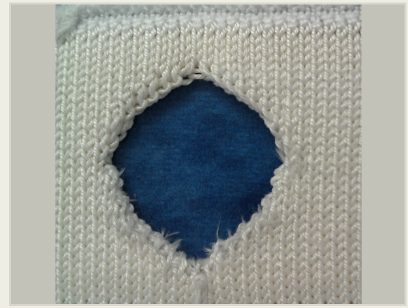
Project Introduction

Use the flexibility and shape formation possibilities inherent in knitting to form thermal protection systems that can be custom fitted to a heat shield carrier structure. Knitted TPS could potentially be used to form 3D and integrated structures. For example, internal struts could be knitted directly into a 2D face sheet, making the joint an integral part of the structure.

Ablative thermal protection materials made from carbon fiber substrates impregnated with resin, especially phenolic, and various other components have and are being developed for demanding atmospheric entries. The carbon fiber can be short or chopped fiber arranged in a rigid (e.g. FiberForm) or flexible substrate (felts) or woven into 2D or 3D structures. The introduction of other fibers to make graded or tailored microstructures are being investigated in a current OCT program. An alternative way to form the substrate and place fibers at exact locations to control local properties is through knitting. Although these techniques are commonly associated with the manufacture of clothing, they have potential advantages in forming substrates for TPS. Knitted fabrics are much more elastic than woven fabrics, and can stretch up to 500%, depending upon the yarn and pattern. Knitted fabrics will drape and fit a form, and knitting can be used to shape a part, including introduction of holes and tabs. Introduction of other fibers in sections or by the stitch is well-known. Commercial knitting companies can make complex structures from a variety of yarns. The field of textile technology has developed many techniques to form and model structures that could be adapted for the development of thermal protection system, including 3D and graded structures. It should be possible to form a thermal protection material by infiltrating phenolic or other polymers and/or additives into the knitted carbon structure. Infiltration techniques developed for rigid and other preforms would be modified for these structures. The advantage of the proposed technique is the ability to make a thermal protection system that can be shaped in advance but has the flexibility to conform to complex shapes. The approach will reduce joints and seams. If successful this approach will provide another tool to solve complex issues in ensuring safe, reliable and efficient thermal protection systems for NASA.

Anticipated Benefits

Novel TPS structures that allow for the incorporation of additional functions or reduce mass can enable both robotic and crewed exploration missions. The Science and Exploration Mission Directorates should be interested as well as the Space Technology program/Office of Chief Technologist. It may also be possible to fold this effort into some of the existing conformable and woven TPS programs that are ongoing.



Sample of knitted ceramic fiber structure with hole

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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

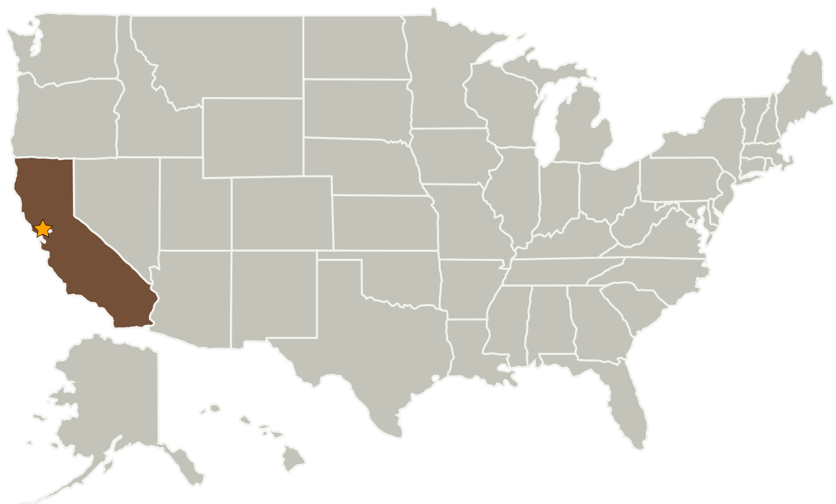
Lead Center / Facility:

Ames Research Center (ARC)

Responsible Program:

Center Innovation Fund: ARC CIF

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Ames Research Center(ARC)	Lead Organization	NASA Center	Moffett Field, California

Primary U.S. Work Locations
California

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Harry Partridge

Project Manager:

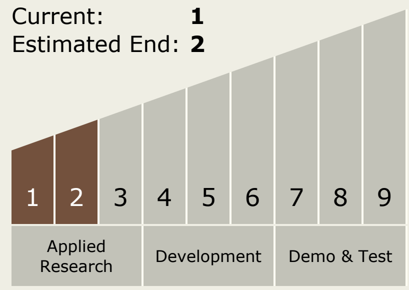
Sylvia M Johnson

Principal Investigator:

Sylvia M Johnson

Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **2**



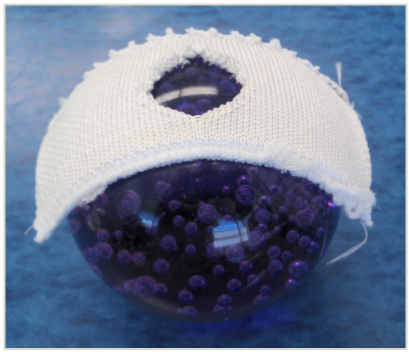
Technology Areas

Primary:

- TX14 Thermal Management Systems
  └─ TX14.3 Thermal Protection Components and Systems
    └─ TX14.3.2 Thermal Protection Systems

Images

Knitted Ceramic Fiber
Sample of knitted ceramic fiber structure with hole
(https://techport.nasa.gov/image/3033)



Knitted Ceramic Fiber Structure
Sample of knitted ceramic fiber structure formed over a 4 cm radius sphere
(https://techport.nasa.gov/image/3034)